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From IT Capabilities to Supply Chain Performance: The Mediating Effects of Supply Chain Agility and Absorptive Capacity

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ABSTRACT

While information technologies have been taken as the competitive tool in improving supply chain performance, its investment cannot guarantee to meet firms' performance expectations. Our understanding about the mechanisms by which IT affects supply chain performance remains unclear. Based on the perspective of dynamic capabilities theory, we derive a model to examine the effects of a firm's IT capabilities, namely IT infrastructure flexibility and IT assimilation on supply chain performance. In particular, we examine the mediating effects of the firm's higher-order organizational capabilities, namely supply chain agility and absorptive capacity on the relationships between IT capabilities and supply chain performance. Results from a survey show that the firm's supply chain agility can fully mediate IT capabilities' influence, while absorptive capacity partially mediate the influences of IT capabilities on supply chain agility. In addition, IT infrastructure flexibility can improve the firm's IT assimilation. Contributions and implications of this study are discussed.

Keywords

IT business value, IT infrastructure, IT assimilation, supply chain agility, absorptive capacity, dynamic capabilities

INTRODUCTION

The globalization of markets, short product life cycles, increased complexity of products and the rapid pace of technology diffusions are increasingly forcing firms to compete as groups or chains, instead of individually (Kandemir et al., 2006). Under this condition, the use of information technology (IT) in managing supply chain processes has emerged as the top priority for firms (Karimi et al., 2001; Ray et al., 2005). Scholars contend that IT, with its power to provide timely, rich, and reliable information, can act as a competitive tool in understanding and meeting customer needs and in improving supply chain performance (Karimi et al., 2001; Ray et al., 2005; Vickery et al., 2003). To reap such benefits, many firms have increased their investment on IT and highlighted such investment as strategic action. However, practical evidences suggest that IT investment in the supply chain management cannot guarantee to meet firms' expectations of a supply chain with stronger performance (Karimi et al., 2001; Wu et al., 2006). Indeed, our understanding about the mechanisms by which IT affects supply chain performance, such as customer service remains unclear, and the empirical research on such mechanisms is lacking (Ray et al., 2005). Therefore, investigating how IT contributes to supply chain is of significance and warrants scrutiny.

To fill the void in the literature, we intend to unveil how IT improves supply chain performance by drawing upon dynamic capabilities theory and the extant literature on supply chain management and IT business value. We propose that a firm's higher-order organizational capabilities, such as supply chain agility and absorptive capacity can serve as mediators in transforming IT capabilities into superior supply chain performance. In particular, we focus on exploring the influences of two specific IT capabilities- IT infrastructures flexibility and IT assimilation capability- on supply chain performance in this study. Specifically, these two IT capabilities are organizationally embedded and reflect the extent to which the firm apply IT for current and future needs of business strategy and value-chain initiative on technical and relational basis (Aral and Weill, 2007; Armstrong and Sambamurthy, 1999; Kumar, 2004; Ray et al., 2005). Current IT business value literature has presented them as critical IT capabilities for firm supply chain management, and suggested that they have great potential to improve the absolute supply chain performance, such as the performance of customer service processes (Ray et al., 2005).

On the other hand, current literature has questioned the direct impacts of IT-related constructs on business value, and further highlighted the necessity to explore IT business value via considering other variables that may mediate or moderate the payoff from IT investment (Pavlou and Sawy, 2006; Rai et al., 2006; Sambamurthy et al., 2003; Wu et al., 2006). Specifically, incorporating concepts of the dynamic capabilities, some scholars contend that firms can better understand and generate the benefits of using IT by combining different IT capabilities to create specific organizational abilities (Pavlou and Sawy, 2006; Rai et al., 2006; Ravichandran and Lertwongsatiem, 2005; Wu et al., 2006). Consistent with this view, the subsequent findings suggest that the firm's ability of sensing and responding to knowledge and change is a critical catalyst in transforming its IT capabilities into business value (Overby et al., 2006; Sambamurthy et al., 2003). In this research, we propose two dynamic capabilities, namely supply chain agility and absorptive capacity as the missing links in the relationships between IT capabilities and supply chain performance. Supply chain agility is proposed to have a direct impact on supply chain performance since it reflects a firm's ability to manage change, such as responsiveness to customer needs and market turbulences mastering (Braunscheidel and Suresh, 2008; Swafford et al., 2006; Swafford et al., 2008). Absorptive capacity which reflects a firm's ability to manage knowledge is hypothesized to have an indirect impact on supply chain performance by reconfiguring supply chain agility.

The rest of this article is organized as follows: part two presents this study's theoretical background and hypotheses development; part three describes the research methodology employed; part four is our data analysis and research findings; and five is our discussion and conclusion.

THEORETICAL BACKGROUND AND RESEARCH MODEL

We apply the dynamic capabilities theory to examine the relationships between IT capabilities and supply chain performance. Dynamic capabilities are normally defined as the abilities of a firm to integrate, build, and reconfigure internal and external competencies, such as technological, organizational, and managerial resources to address environmental turbulence (Eisenhardt and Martin, 2000; Teece et al., 1997). Following the dynamic capabilities theory, current supply chain management and IS literature suggests that these intangible and knowledge-based organizational capabilities are the critical sources of firm performance (Cepeda and Vera, 2007; Overby et al., 2006; Rai et al., 2006; Sambamurthy et al., 2003; Vickery et al., 2003). On the other hand, the literature indicates that IT capabilities cannot by themselves create superior supply chain performance for a firm. They need to be blended with interorganizational processes to develop higher-order organizational capabilities for information transferring, market sensing, operations and workflow coordination, and market turbulences mastering (Rai et al., 2006). Sambamurthy and his colleagues (2003) have proposed a useful theoretical foundation for understanding the relationships among IT capabilities, dynamic capabilities, and firm performance. They point out that IT impacts firm performance through organizational ability of knowledge management and change management. In line with this, more scholars have contended that two dynamic capabilities, namely supply chain agility which reflects a firm's ability to manage change (e.g., Overby et al., 2006; Swafford et al., 2008) and absorptive capacity which reflects a firm's ability to manage knowledge (e.g., Malhotra et al., 2005; Pavlou and Sawy, 2006) are two important higher-order organizational capabilities in the process of transforming IT capabilities into supply chain performance.

Supply Chain Agility

Agility has been widely presented as the critical higher-order organizational capabilities to improve firm competitive performance in current business environments (Overby et al., 2006; Sambamurthy et al., 2003). However, as Swafford et al.

(2008) note, "agility at the organizational level is a broad concept." (p. 288) Thus, we followed their suggestion by focusing only on agility in a firm's supply chain. Supply chain agility refers to the capability of the firm in conjunction with its key partners to adapt or respond in a speedy manner to a changing marketplace (Braunscheidel and Suresh, 2008; Swafford et al., 2006; Swafford et al., 2008; Van Hoek et al., 2001).

The extant supply chain management literature suggests that there are four primary dimensions of supply chain agility (Braunscheidel and Suresh, 2008; Van Hoek et al., 2001; Yusuf et al., 2004), i.e., visibility, joint planning, process integration and shared values. In particular, visibility is defined as the extent to which information about the marketplace is easily available for supply chain partners. Joint planning refers to the ability to successfully cooperate with supply chain partners in the planning of supply chain practices. Process integration focuses on the ability to master change across the supply chain through streamlined and automated supply chain activities with supply chain partners. Shared values reflects the extent to which partners agree about the joint strategic goals of the supply chain (Braunscheidel and Suresh, 2008; Swafford et al., 2006; Swafford et al., 2008; Van Hoek et al., 2001).

Since supply chain agility is "all about customer responsiveness and mastering market turbulences" (Van Hoek et al. 2001), it is accepted that supply chain agility can lead to superior supply chain performance. For example, Swofford et al. (2008) empirically demonstrate that supply chain agility can directly affect the performance of a firm's competitiveness. In this view, we contend that superior supply chain agility enables a firm to obtain superior supply chain performance directly too. In particular, supply chain performance refers to the extent to which a firm can apply all the necessary resources and capabilities to meet customer requirement and to respond to market change in a responsive manner (Harrison et al., 2004). A firm equipped with a high supply chain agility may increase product customization, on-time delivery, new market entering and customer services (Swafford et al., 2008), which are all critical for supply chain performance.

H 1: A firm's supply chain agility is positively related with its supply chain performance

Absorptive Capacity

Absorptive capacity refers to a firm's ability to acquire, assimilate, transform, and exploit new knowledge to produce dynamic organizational capabilities (Cohen and Levinthal, 1990; Malhotra et al., 2005). It has been viewed as strategic asset which allows firms to manage their knowledge when the opportunities or needs arise. More importantly, absorptive capacity enables a firm to develop its capabilities continuously, and to embed such capabilities in its operations (Vorhies et al., 1999).

Overby et al.(2006) contend that a firm's absorptive capacity reflects the firm's ability to manage knowledge, such as extending its knowledge reach and richness. According to Sambamurthey et al. (2003), the firm's knowledge reach and richness can facilitate its customer partnering and operational agility. Similarly, other scholars propose that firms with superior absorptive capacity are likely to be more adept at sensing changes in their external environment and responding to these changes (Malhotra et al., 2005). In this view, we assert that in order to build supply chain agility, the firm has to have absorptive capacity in place to extend its knowledge reach and richness. In particular, acquiring the necessary information and knowledge from the market allows the firm improves the visibility of supply chain, and assimilating, transforming and exploiting such information and knowledge extends the firm's knowledge stock to facilitate its jointed planning and process integration with channel partners (Malhotra et al., 2005). Further, the extended knowledge stock improves the firm's understandings about the market and about its partners' opinions and values, and then facilitates the development of shared values with them (Tu et al., 2006).

H2: A firm's absorptive capacity is positively related with its supply chain agility

IT Capabilities

IT capabilities refer to a firm's ability to assemble, integrate, and deploy IT resources to fulfill its business needs (Bharadwaj, 2000; Karimi et al., 2007; Saraf et al., 2007; Wade and Hulland, 2004). Current literature has shown a wide variety of IT

capabilities and has investigated their business value in the context of supply chain management, such as IT infrastructure, IT managerial capabilities, IT assimilation capability, IT planning capability, enterprise system-enabled capabilities, and so on (Rai et al., 2006; Ravichandran and Lertwongsatiem, 2005; Wade and Hulland, 2004; Wu et al., 2006). In the context of supply chain, Ray et al. (2005) suggested that flexible IT infrastructure and shared knowledge between IT and business functions were two critical IT capabilities which can contribute to the performance of the customer service process. Ravichandran and Lertwongsatiem (2005) have noted that IT capabilities have the dimension of operational competence, which reflects a firm's ability to provide reliable and consistent IT support to the business, and the dimension of transformational competence, which represents the ability to transform the firm using IT. In this view, we focus on two specific IT capabilities of a firm, namely IT infrastructure flexibility which reflects the firm's operational competence and IT assimilation which reflects the firm's transformational competence or shared knowledge between IT and business functions. Further, to create superior supply chain performance, firms must align their IT capabilities with inter-organizational processes. Therefore, based on dynamic capabilities theory and extant IS literature, we propose that these two dimensions of IT capabilities facilitate the firm to develop higher-order organizational capabilities, namely supply chain agility and absorptive capacity, which in turn, help the firm enhance supply chain performance.

IT infrastructure flexibility

IT infrastructure flexibility refers to a firm's shared set of technological resources that can provide the foundation for rapid development and implementation of present and future IT applications (Bharadwaj, 2000; Ravichandran and Lertwongsatiem, 2005; Ray et al., 2005). It reflects the firm's ability to provide reliable and consistent IT support to the business. Researchers and practitioners have treated it as an organizational capability that is critical in developing, building, and assimilating other organizational capability (Bharadwaj, 2000; Wade and Hulland, 2004). In this view, we contend that IT infrastructure flexibility can help build higher-order organizational capabilities.

Generally, absorptive capacity requires "the structure of communication between the external environment and the organization, as well as among the subunits of the organization, and also on the character and distribution of expertise within the organization.'' (Cohen and Levinthal, 1990 p.132) IT infrastructure flexibility reflects the firm's platform readiness for updating current infrastructure, integrating disparate data source, resisting system failure and adding new applications (Kumar, 2004). In this view, IT infrastructure flexibility can provide the structure to facilitate the communication that absorptive capacity required. In particular, IT infrastructure flexibility enables the firm to successfully adopt and implement standards for the components of IT infrastructure (Ray et al., 2005), and then supports the firm standardize its platform and data. This standardization would help the firm extend its information and knowledge reach and richness via sharing all types of information across systems, business units and network expeditiously and effortlessly (Byrd and Turner, 2001; Ray et al., 2005; Rockart et al., 1996). For example, with IT infrastructure flexibility, the firm would more easily adopt and implement the prevalent open-standard inter-organizational systems (IOS)-Internet technologies, and then achieve efficient flows of information with ease and at low cost (Frohlich, 2002; Zhu et al., 2006). In this view, we propose that IT infrastructure flexibility can facilitate the firm to acquire, assimilate, transform, and exploit inside and outside information and knowledge to improve its absorptive capacity.

H3a: A firm's IT infrastructure flexibility is positively related with its absorptive capacity.

On the other hand, flexibility is the requisite element of supply chain agility (Braunscheidel and Suresh, 2008; Swafford et al., 2008). In addition, it is the intangible, but important aspect of the IT infrastructure in the rapidly changing business environment (Byrd and Turner, 2001; Ravichandran and Lertwongsatiem, 2005). Thus, it is no surprise to find that researchers and practitioners have treated IT infrastructure flexibility as critical factor for supply chain agility (Swafford et al., 2006; Swafford et al., 2008). Indeed, IT infrastructure flexibility can help build stronger supply chain agility in four ways. First, IT infrastructure flexibility allows the firm to exchange relevant and important information with its supply chain partners timely (Chung et al., 2005; Karimi et al., 2001; Kumar, 2004). This would improve the visibility of information in the supply chain. Second, the deployment of flexible IT infrastructure in the supply chain can reduce communication cost between partners and then facilitate the development of joint plans or schedules (Ray et al., 2005). Third, IT infrastructure flexibility can improve process integration between channel partners (Rai et al., 2006). It facilitates the process integration across the supply chain in areas such as procurement and order execution (Frohlich, 2002). Fourth, IT infrastructure

flexibility offers partners a foundation to exchange their values and ideas, and thus promotes them to reach a shared cognition and values for their supply chain. In summary, IT infrastructure flexibility provides a reliable and consistent IT platform to support the firm to launch a new business application in a very short time (Bharadwaj, 2000), and enables it to respond to emerging opportunities or to neutralize competitive threats swiftly (Ray et al., 2005). Thus, the firm's IT infrastructure flexibility can ensure the firm develop a high level supply chain agility (Chung et al., 2005; Rai et al., 2006).

H3b: A firm's IT infrastructure flexibility is positively related with its supply chain agility.

IT assimilation capability

IT assimilation capability refers to the ability of a firm to effectively apply IT in supporting, shaping, and enabling its business strategies and value-chain activities (Armstrong and Sambamurthy, 1999). It reflects the extent to which the focal firm has been transformed to IT-enabled organization. In particular, it indicates the extent to which IT applications have been diffused in organizational process, as well as how those applications have been effectively used within and across the firm, and finally enable the conduct of business strategies and value-chain activities associated with these IT applications. Scholars have suggested that IT assimilation capability is essential to firm competitiveness, since it facilitates the embedment of the IT value in business processes and yields specific utility to achieve IT business value (Armstrong and Sambamurthy, 1999; Liang et al., 2007; Tarafdar and Gordon, 2007). Following this logic, we propose that IT assimilation capability facilitates the firm develop higher-order capabilities.

To achieve high IT assimilation capability, the firm needs to delivery the IT products and service within and across itself based on its IT professionals' experience, competencies, commitment, and values (Armstrong and Sambamurthy, 1999; Byrd and Turner, 2000; Liang et al., 2007). The process of this delivery involves the exchange of information and knowledge that is essential to manage the IT resources effectively within and across the firm. Thus, the firm's absorptive capacity would be improved in the process of IT assimilation in the following ways. First, by delivering expertise within and across the firm, IT assimilation capability facilitates intra- and inter-organizational knowledge acquisition. Second, IT assimilation capability provides easy access to stored knowledge, and enables the firm to interpret and to synthesize new and stored knowledge. Third, IT assimilation capability can enhance the firm's problem-solving capability with IT applications and enable it to transform knowledge to generate new ideas. Fourth, IT assimilation capability enables the firm to pursue new business application with IT applications, thus help the firm exploit superior knowledge. In summary, through assimilating IT applications, the firm ensures different functions deliver their expertise to each other, and then facilitates them contribute their specific information and knowledge about the market to extend the firm's knowledge reach and richness as a whole (Piccoli and Ives, 2005; Ravichandran and Lertwongsatiem, 2005). Under this condition, multiple firm members would be easier to recognize, understand, communicate, assimilate, apply and exploit diverse knowledge within and across the firm, and then improve the firm's absorptive capacity.

H4a: A firm's IT assimilation capability is positively related with absorptive capacity.

High IT assimilation capability not only indicates the effective application of IT resources in the firm, but also reflects the effective application across the firm's supply chain. Generally, supply chain agility involves the dimensions of reach and range of channel activities, and reflects the quality of relationships amongst networked firms (Yusuf et al., 2004). In other words, this agility requires the high reach and range of integration of resources across the supply chain processes. Indeed, in the process of assimilating IT resources in the supply chain, the firm is able to promote such resource integration to develop superior supply chain agility that is otherwise hard to achieve without IT. Specifically, as a relationship asset, IT assimilation capability supports the teaming and free flow of knowledge between IT function and non-IT functions extensively (Piccoli and Ives, 2005; Ravichandran and Lertwongsatiem, 2005; Wade and Hulland, 2004). This principles of free flow of knowledge across functions should extend to entire value chains, and smooth out the flow of active information and resource sharing within and across firms (Kearns and Sabherwal, 2006; Yusuf et al., 2004). Both the information and resource sharing would further extend the reach and range of supply chain related information and improve information visibility. Meanwhile, the improvement of IT assimilation capability enables the firm to coordinate planning process at a more extensive reach and range through using IT, which is critical in organizing and allocating resources to achieve supply chain agility (Devaraj et al., 2007; Frohlich, 2002). In addition, assimilating IT resources in the supply chain is likely to improve process integration with

partners at large reach and range, such as procurement, order execution, inventory management and design to address the changing market needs, which cannot realize without IT (Rai et al., 2006; Ray et al., 2005; Sambamurthy et al., 2003). Further, the improvement of IT assimilation capability facilitates the exchange of ideas and value within and across firms (Kearns and Sabherwal, 2006). This enables supply chain members to understand each other and then to establish shared value for their supply chain.

H4b: A firm's IT assimilation capability is positively related with its supply chain agility.

Although a firm's IT infrastructure flexibility and IT assimilation capability are equally important for supply chain performance, the achievement of superior IT assimilation capability within and cross the firm is complex and difficult (Armstrong and Sambamurthy, 1999; Liang et al., 2007; Tarafdar and Gordon, 2007). Indeed, scholars have presented that the extent to which a firm's IT assimilation is feasible is determined by the firm's IT infrastructure (Armstrong and Sambamurthy, 1999; Tarafdar and Gordon, 2007). This indicates that only when the firm has the superior ability to provide reliable and consistent IT support, it can transform itself more IT-enabled. According to Armstrong and Smabamurthy (1999), IT infrastructure flexibility can improve IT assimilation capability since it enables a firm to enhance inter- and intra-organizational connectivity, alter competitive business strategies, and facilitate the development of high level technical knowledge. Meanwhile, IT infrastructure flexibility reflects a high level of IT applications availability, this would enhance the ability and willingness of business managers to shape their business with innovative applications of IT (Sambamurthy and Zmud, 1996; Tarafdar and Gordon, 2007). For example, the newly introduced open-standard Internet technologies allow a firm to achieve efficient flows of products, services, information and capital with ease of implementation, ease of accessing a new business channel, ease of use and low cost (Sanders, 2007; Teo et al., 2006), which enables the firm to provide maximum value to channel partners (Frohlich, 2002; Zhu et al., 2006). For most firms, such benefits could serve as an impetus for the assimilation of advanced IT applications.

H5: A firm's IT infrastructure flexibility can positively impact its IT assimilation capability.

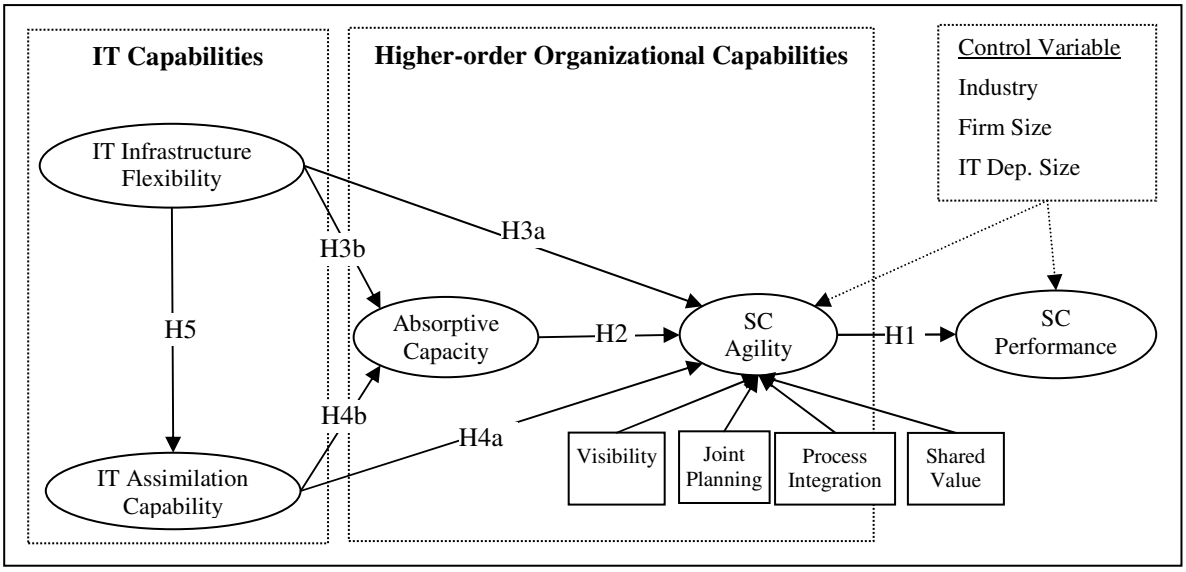

Figure 1. Research Framework

RESEARCH METHOD

Sample

To test our research model, we employed the survey method to collect data. Specifically, we sent 600 questionnaires to senior executives, such as the vice president of information technology, chief technology officer or chief operation officer based on

the name list provided by an institute which is famous for its executives training programs. Finally, we received 293 returned questionnaires. Seven incomplete questionnaires were discarded. Thus, we obtained 286 useful questionnaires and a response rate of approximately 48%. Further, we tested the non-response bias by the method suggested by Armstrong and Overton (1999). That is, the Chi-squares of the key measurement items of the responses from the first 25% of the respondents were compared with that of the final 25%. Our results indicated no significant differences between these two groups on key measures.

Measures

An English questionnaire was developed based on previously validated measures. All items were measured with 5-point Likert scales, ranging from "strongly disagree" to "strongly agree". We used six items to measure supply chain performance which adapted from Stank et al. (2001). They measured the firm's performance of market responsive and customer service. The items measuring IT infrastructure flexibility were adapted from Ray et al.'s (2005) and Sarah et al.'s (2007) work, and the items for measuring IT assimilation capability were adapted from Liang et al.'s (2007) paper. We used the scales from Ettlie and Pavlou (2006) to test absorptive capacity. In addition, the extent of a firm's supply chain agility was assessed on the following four dimensions in prior research: visibility (Chen et al., 2004); joint planning (Simatupang and Sridharan, 2005); process integration (Lee and Whang, 2004); shared value (Li and Lin, 2006). Further, all the measures related to supply chain activities point out that partners refer to the respondents' dominant partner of their primary product(s) or product line(s) who commands a significant proportion of firm business as Rai et al. (2006) suggested. Given the survey was executed in China, we translated the questionnaire into Chinese firstly and then back-translated to English so as to ensure equivalence of meaning between the English and Chinese versions.

DATA ANALYSIS AND RESULTS

Since all data were perceptual and collected from a single source at one point in the time, we used the Harman's one-factor test on the measurement items to test the possible common method bias. The results presented that all items can be categorized into six constructs with eigenvalues greater than 1.0 and accounted for 65.31% variance. Meanwhile, the first construct of these six constructs did not account for the majority of the variance. This indicated that common method bias was not a serious concern in our study.

According to Chin (1998), if a latent variable is assumed to be caused by its items, it is a formative construct. Thus, in our study, the construct of supply chain agility was identified as the formative constructor. Since our model contains formative construct, and the research is predictive, partial least square (PLS) was chosen to analyze the data.

Measurement model

To test our model, we firstly assessed the measurement model's convergent validity and discriminant validity. For convergent validity, we assessed by the reliability of items, Cronbach's alpha, composite reliability of constructs, and Average Variance Extracted (AVE). The results of Confirmatory Factor Analysis (CFA) present that the loading of all items are up 0.60 criteria. As shown in table 1, Cronbach's Alpha ranged from 0.811 to 0.891 and are above the 0.60 recommended level. Also, the values of composite reliability range from 0.876 to 0.925 and are above the 0.70 recommended level (Fornell and Larcker, 1981); and AVE scores for every construct ranged from 0.605 to 0.754 and are above the 0.50 recommended level. It indicates that our measurement has satisfactory convergent validity. On the other hand, according Fornell and Larcker's (1981) recommendation, the relationship between correlations among constructs and the square root of AVEs can be used to assess items' discriminant validity. As Table 2 shown, the square root of AVEs for each construct is greater than the correlations between constructs, which confirms the discriminant validity.

	Items	Cronbach's Alpha	Composite Reliability	AVE
IT Infrastructure Flexibility	4	0.874	0.913	0.724
IT Assimilation capability	4	0.811	0.876	0.639
Absorptive capacity	4	0.848	0.897	0.685

SC Performance	6	0.870	0.901	0.605
Visibility	3	0.811	0.888	0.726
Joint Planning	4	0.846	0.897	0.684
Process Integration	4	0.852	0.900	0.693
Shared Value	4	0.891	0.925	0.754

Table 1. Results of Confirmatory Factor Analysis

	Mean	S.D.	ITF	ITA	ABC	VIS	JOP	PRI	SHV	SCP	IND	SIZE	ITS
IT Infrastructure Flexibility (ITF)	3.39	0.93	*0.85*										
IT Assimilation Capability (ITA)	3.63	0.88	0.69	*0.80*									
Absorptive capacity (ABC)	3.51	0.77	0.54	0.59	*0.83*								
Visibility (VIS)	3.64	0.91	0.43	0.49	0.52	*0.85*							
Joint Planning (JOP)	3.20	0.91	0.46	0.48	0.48	0.58	*0.83*						
Process Integration (PRI)	3.24	1.01	0.53	0.54	0.51	0.59	0.72	*0.83*					
Shared Value (SHV)	3.47	0.87	0.35	0.44	0.56	0.57	0.56	0.59	*0.87*				
SC Performance (SCP)	3.69	0.74	0.30	0.39	0.43	0.44	0.43	0.42	0.49	*0.78*			
Industry (IND)	NA	NA	-0.04	-0.02	-0.03	-0.07	-0.09	-0.05	-0.06	-0.18	NA		
Firm Size (SIZE)	NA	NA	0.27	0.27	0.18	-0.01	0.08	0.13	0.10	0.18	-0.05	NA	
IT Dep. Size (ITS)	NA	NA	0.38	0.39	0.24	0.12	0.12	0.21	0.15	0.16	-0.12	0.70	NA

Table 2. Mean, standard deviation, and correlation

Note: The diagonal elements are the square root of the AVE.

Structural model

In Figure 2, we present the results of the structural model. In this study, one indicator for supply chain agility, namely joint planning did not present significant formative weights. To retain the content validity, we retained this non-significant sub-construct, namely joint planning in our model as Rai et al. (2006) suggested. The results also present that the control variables, namely industry, firm size and IT department size do not play significantly in the model. In addition, the model explains 32 to 48 percent of the variances. The results also demonstrate that most hypotheses are supported, except H3a (on the relationship between IT infrastructure flexibility and supply chain agility). In particular, the results show that a firm's supply chain agility (β=0.52, $p<0.01$) is positively related to its supply chain performance and thus H1 is supported. Meanwhile, the significant relationship between the firm's absorptive capacity (β=0.42, $p<0.01$) and its supply chain agility support H2. On the other hand, IT infrastructure flexibility only can significantly impact absorptive capacity (β=0.27, $p<0.05$), but cannot significantly influence supply chain agility (β=0.13). Thus, H3a is not supported and H3b is supported. In contrast, IT assimilation capability was positively related to supply chain agility (β=0.27, $p<0.05$) and absorptive capacity (β=0.41, $p<0.01$) simultaneously, and therefore H4a and H4b are supported. The results present that a firm's IT infrastructure flexibility can significantly influence its IT assimilation capability (β=0.69, $p<0.01$), and H6 is supported too.

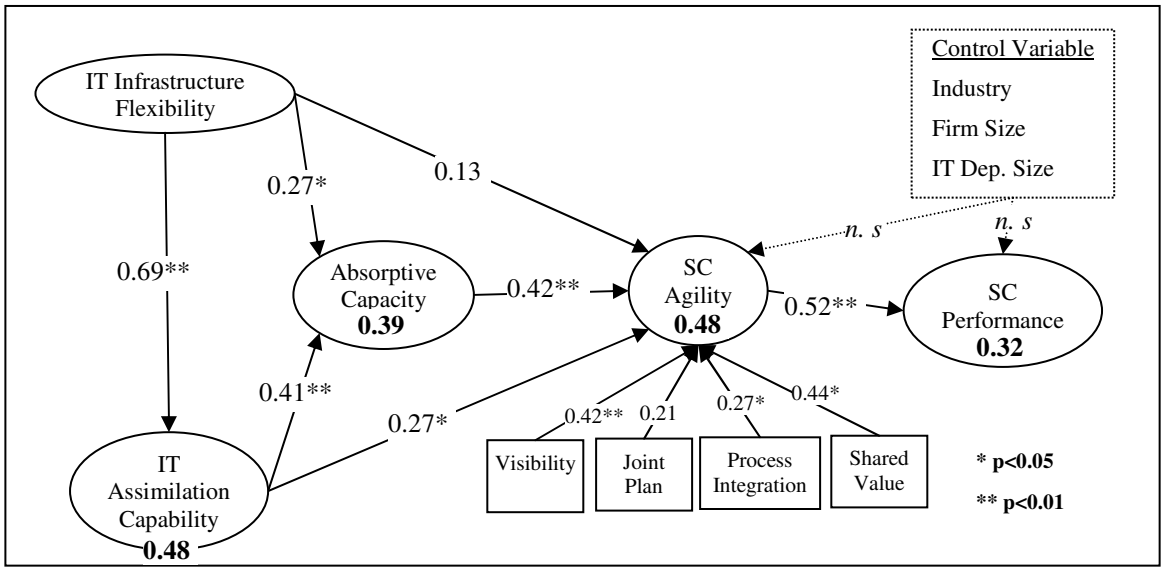

Figure 2. PLS results of the research framework

Mediating effect testing

To test the mediating effect of the higher-order organizational capabilities, namely supply chain agility and absorptive capacity, we adopted Baron and Kenny's (1986) three-step method. To prove mediations, the results ought to be able to, first, show that the independent variable (IV) can directly predict the dependent variable (DV); second, show that IV should significantly predict the mediator (M); last, assess the significance of the path coefficients between IV and DV when controlling for M. If M is significant but IV is not, M's mediating effect will be full. If both M and IV are significant, M's mediating effect will be partial.

As Figure 3 shown, Model B with supply chain agility and Model C with both supply chain agility and absorptive capacity explain significantly higher variance in supply chain performance than the direct model (Model A). This indicates that it is necessary to include higher-order organizational capabilities to more accurately predict the influences of IT capabilities on supply chain performance from a predictive perspective. Notably, Model B suggests that both IT infrastructure flexibility and IT assimilation capability have significant direct effect on supply chain agility, but have non-significant direct impact on supply chain performance. These findings suggest that supply chain agility is not IT free. It can fully mediate the influences of IT infrastructure flexibility and IT assimilation capability on supply chain performance, related to Model A. Further, as model C shown, the direct effects of IT infrastructure flexibility and IT assimilation capability on supply chain performance are insignificant too, thus further validating the full mediating effects of supply chain agility. On the other hand, when we tested the mediating effects of absorptive capacity on the relationship between IT capabilities and supply chain performance, the insignificant relationship between absorptive capacity and supply chain performance indicate that it cannot play such mediation role. To further explore the role of absorptive capacity, we tested its mediating effects on the relationship between IT capabilities and supply chain agility. The separate model which only includes IT capabilities and supply chain agility presents that IT capabilities can directly impact supply chain agility. Further, when we assessed the mediating effects of absorptive capacity on the relationship between IT capabilities and supply chain agility, in the model with IT capabilities, absorptive capacity and supply chain agility only, the significant relationships among these three constructs validate the partial mediating effects of absorptive capacity. Meanwhile, Model C also indicates the mediating effects of absorptive capacity.

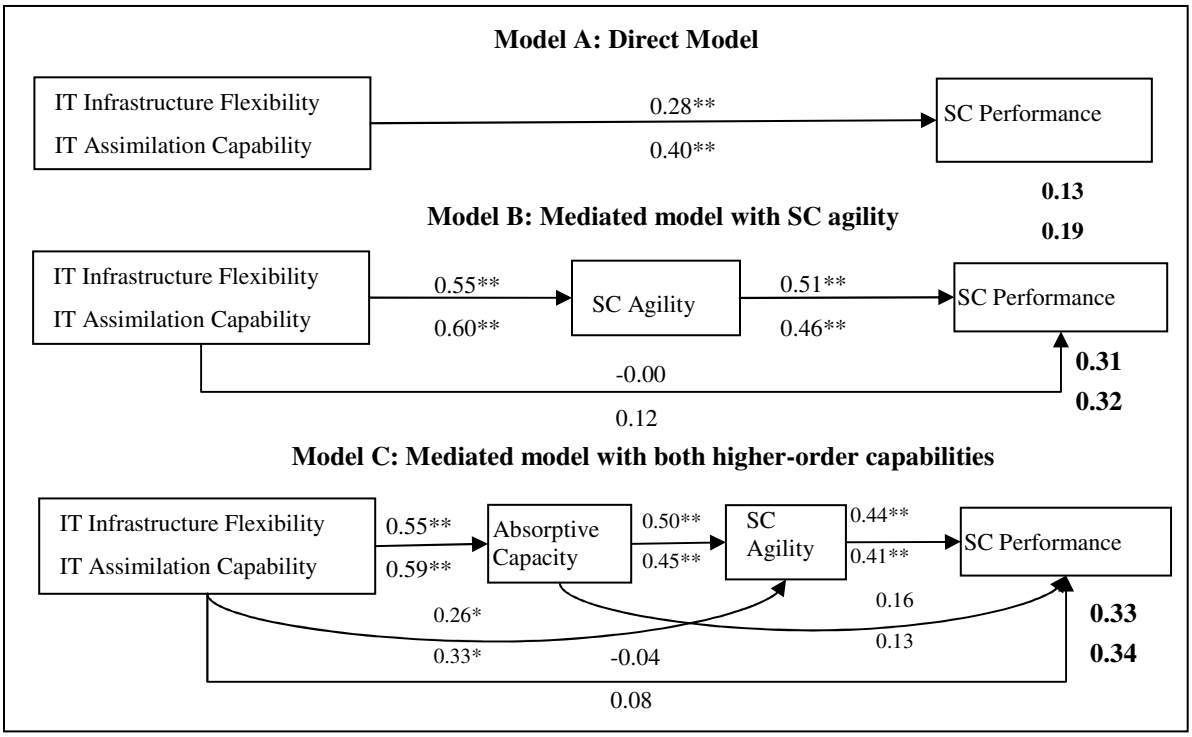

Figure 3. Test of the mediating role of supply chain agility and absorptive capacity

DISCUSSION AND CONCLUSION

The findings of this study are largely consistent with the proposed theoretical foundation. Findings show that a firm's higher-order organizational capabilities, namely supply chain agility can serve as the important mediator in transforming specific IT capabilities, namely IT infrastructure flexibility and IT assimilation capability, into superior supply chain performance. Also, the firm's absorptive capacity can partially mediate the influences of IT capabilities on supply chain agility, and directly affect supply chain agility which could finally directly influence supply chain performance.

IT infrastructure flexibility is not found to directly impact supply chain agility. As the results of our mediating effects test shown, the effects of IT infrastructure flexibility on supply chain agility could be partially mediated by a firm's absorptive capacity. This indicates that to improve supply chain agility through efficient using of flexible IT infrastructure, the firm needs to apply its technical platform to support knowledge management firstly, and then improve its ability to manage change based on the ability of knowledge management.

Our study makes three major theoretical contributions. First, this study enriches the research investigating the effects of IT capabilities in enhancing business performance in general and supply chain performance in particular. Although scholars have investigated the business value of a wide variety of IT capabilities, few conduct their research in the context of supply chain management. Our research provides insights into the business value of operational and transformational IT capabilities, i.e., IT infrastructure flexibility and IT assimilation capability (Ravichandran and Lertwongsatiem, 2005) to supply chain performance. Second, this research goes beyond the singular focus on IT capabilities and empirically explores the role of supply chain agility as a key mediator between IT capabilities and supply chain performance. It unveils the mechanisms through which IT capabilities affect supply chain performance by investigating the complementary effects of IT capabilities on higher-order organizational capabilities. As such, it extends current IT business value research and shed light on how IT capabilities lead to improved business performance. Third, this research also explores the role of absorptive capacity in the influencing process of IT capabilities. It suggests that absorptive capacity not only directly impacts supply chain agility, but also partially mediates the influences of IT capabilities on supply chain agility. This finding enriches our current understanding of the relationships among IT capabilities, absorptive capacity and supply chain agility. Specifically, it

empirically extends the application of the conceptual framework proposed by Sambamurthy et al. (2003) and provides new avenues for future research to investigate the capabilities-enhancing role of IT in the supply chain management context.

This research also has practical implications for firms implementing IT to improve supply chain performance. First, our research provides insights into the importance of two specific IT capabilities for supply chain performance. In particular, our research suggests that managers should focus their IT investment on the improvement of firms' operational and transformational IT competence. For example, to ensure reliable and consistent IT support for business functions, managers should enhance the firm's IT infrastructure flexibility. Meanwhile, they should try to assimilate IT and transform their business processes simultaneously. Second, the results of this study suggest that managers can improve the extent of the firm's IT assimilation through increasing the flexibility of IT infrastructure. Third, the research provides managers with guidelines for realizing the business value of IT investment. That is, managers need to transfer firms' IT capabilities into higher-order organizational capabilities, namely the ability to effectively manage knowledge and to effectively respond to existing environmental changes, so that they can reap the benefits of IT capabilities. In other words, supply chain agility and absorptive capacity are necessary for realizing IT business value. Fourth, our study indicates that supply chain agility is a higher order construct. Thus, managers should take all the interrelated dimensions of supply chain agility into consideration when they are trying to enhance their supply chain performance.

It is important to evaluate this study's results and contributions in light of its limitations. First of all, there may exist other IT or organizational capabilities that can affect supply chain performance. Future research can extend our study by examining other capabilities' effects. Second, although we have found that common method bias was not a serious concern for this study through Harman's one-factor test, it may be also an issue since we collected data with a single source. Meanwhile, all major constructs in this research were measured by single respondents' perceptions, which were subjective. We urge that future research will use multiple data sources. Finally, although market responsiveness and customer service have been treated as the essential elements of supply chain performance, there might be other measures in the literature. A measure covers more extensive dimensions may be more valuable.

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